

NESTING BEHAVIOR OF A RAGGIANA BIRD OF PARADISE

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ABSTRACT.—We made observations of a nest of a Raggiana Bird of Paradise (*Paradisaea raggiana*) for 22 days. The single nestling was attended only by the female and was fed only arthropods until day 5, and thereafter a mix of arthropods and fruit. Evidence from regurgitation of seeds at the nest indicates that the parent subsisted largely on fruit. This dietary dichotomy conforms to that of other polygynous birds of paradise and accords with socioecological predictions concerning single-parent nestling care. Received 3 Aug. 1993, accepted 1 Feb. 1994.

Many aspects of the life history of birds of paradise (Paradisaeidae) are at least superficially understood (Gilliard 1969, Cooper and Forshaw 1977, Diamond 1981, Beehler 1989). One notable exception is nesting biology which is inadequately documented for many paradisaeid species (Cooper and Forshaw 1977). In spite of recent contributions (Pruett-Jones and Pruett-Jones 1988; Frith and Frith 1990, 1992, 1993a, b; Mack 1992), the nests of 13 species remain undescribed, and 26 species have never been studied at the nest (Cooper and Forshaw 1977; Beehler, unpubl.). Here we provide the first detailed description of nesting behavior of the Raggiana Bird of Paradise (*Paradisaea raggiana*) in the wild, one of the best-known members of the family, and Papua New Guinea's national symbol.

The Raggiana Bird of Paradise is a common, vocal, and widespread species of forest and edge that inhabits lowlands and hills of southern, central, and southeastern Papua New Guinea (Cooper and Forshaw 1977). It is strongly sexually dimorphic. The male is larger than the female and exhibits an emerald green throat, an elongated central pair of tail wires, and dense silky orange (or in some subspecies orange-red) pectoral plumes that are erected into a cascade during vocal and kinetic courtship display. By contrast, the female (and subadult male) is colored in browns, tans, and dull yellow and typically is silent and unobtrusive. The Raggiana displays in classic lek pattern, where several males occupy canopy branches of a forest tree and display to and mate with visiting females (Frith 1981, Beehler 1988).

Subsequent to mating, females receive no assistance from males in nest building, incubation, or raising offspring (Cooper and Forshaw 1977).

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Female-only nest care appears universal among lek-breeding bird species (Bradbury 1981, Beehler 1987) and apparently places considerable demands on the parent provisioning offspring.

In the Ribbon-tailed *Astrapia* (*Astrapia mayeri*), the largely frugivorous female feeds her offspring a diet that includes substantial animal prey (Frith and Frith 1993a). Dharmakumarsinhji (1943) reported that a captive Raggiana female fed her nestling orthopterans. Other zoo-bred *Paradisaea* species were fed arthropods and fruit (Muller 1974, Todd and Berry 1980, Searle 1980). It has been predicted that in the wild, Raggiana females might feed their nestling a diet mostly of arthropods (Beehler 1987) in order to satisfy the offspring's demands for protein and lipid (Snow and Snow 1979).

STUDY AREA AND METHODS

We made observations at Varirata National Park, 20 km E of Port Moresby, Central Province, Papua New Guinea, 9°30'S, 147°20'E, 840 m asl, in July and August 1990. On 20 July 1990, BMB flushed a presumed female Raggiana. The following day, after flushing the bird again, BMB discovered its nest, hidden in climbing bamboo, 7.5 m up in a small tree (*Rhus taitensis*: Anacardiaceae). Observations began on 27 July and continued until 17 August when the nestling died. The nest was observed for 170 h during the 22 days, approximately 60 h before the nestling hatched (5 August, ca 10:45 h) and 110 h during the 12 days that it lived. Activity at the nest was observed from a blind on the ground, constructed of saplings and black plastic, 22 m from the nest tree, using a spotting scope with 20× eyepiece. The nest was observed during 22 days. Observation periods began ca 07:00 h and usually continued until 16:00, in some cases with interruptions. All nesting behaviors were recorded, including (1) presence or absence of the parent; (2) arrival and departure times; (3) pattern of nest arrival; (4) time spent feeding the chick; (5) chick maintenance; and (6) numbers and kinds of food delivered to the chick.

The duration and timing of parental activity, such as egg turning and nestling attendance, were timed when possible. Observations, in which head or bill movements and regurgitations were counted, were also made. The dead nestling was preserved in an ethanol:formalin solution and necropsied at the Dept. of Pathology, National Zoological Park, Washington, D.C.

RESULTS

During the nine days preceding egg hatching, the female incubated for ca 75% of the time (Fig. 1). On 2 August it rained heavily, and the bird incubated for >90% of the observation period, not leaving the nest until the rain stopped. After the nestling hatched, the proportion of time the parent was present steadily decreased to an average of 33% of the time over the last four days. Absences from the nest did not exceed 45 minutes until 11 August when the female made a series of afternoon absences, followed by little or no brooding, and was once absent for more than an hour. The nestling was a few hours over six days old at that point. This

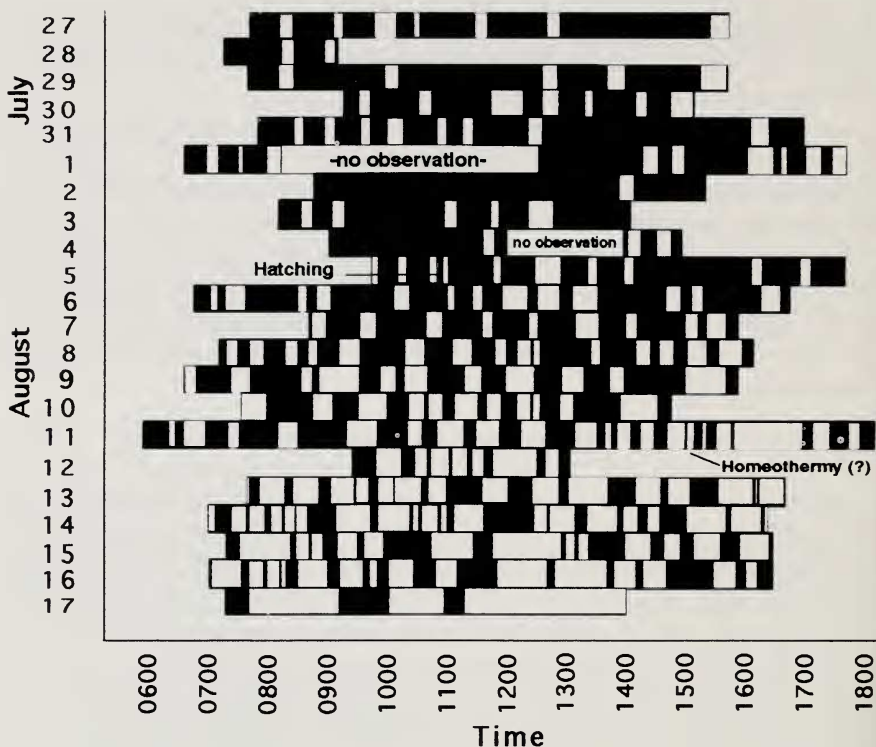


FIG. 1. Time budget for nesting female Raggiana Bird of Paradise. Black represents time female is at nest, white away from nest.

change in behavior by the female may have coincided with homeothermy of the nestling.

The female remained on the nest during rain, but if rain began while she was away from the nest, she did not return immediately. This was apparent on 16 August when rain began at 11:11 h, and intermittent downpours occurred throughout the afternoon. On four occasions the female failed to return when rain started, and the nestling was left unattended in the rain for a total of more than 65 min. The following day the female remained absent for protracted periods (Fig. 1) and did not follow her usual sequence of feeding and nestling maintenance. The nestling was not visible and was probably not capable of taking food due to its weakened state. The female left at 11:20 h and had not returned when observation ended at 14:05. The dead chick was cold when it and the nest were collected at 15:30 h.

The nest was a bowl-shaped structure with an exterior diameter of ca

150 mm and an interior diameter of ca 110 mm. It was made of entwined supple roots, vines and leaves, lined with an extensive mat of thin, wire-like fern stems. A live epiphytic orchid and live fern were part of the structure of the cup.

The female, with two brief exceptions, sat in the same position nearly perpendicular to our line of sight. She normally departed from the far side of the nest via a small branch. On several occasions, she left from the near side of the nest. She periodically stood in the nest with her head down, presumably rolling the egg.

The female periodically stood in the nest and attended the nestling. These bouts of nestling maintenance were accompanied by occasional nest probing. By the time the nestling died the female was in a constant half-stand or crouch, usually with her back feathers somewhat elevated.

The female was constantly alert during the incubation and nestling periods. Her head was almost constantly moving, shifting position in small jerky movements at intervals of less than a second. The only major change in this behavior occurred during rain, when the bird became more quiescent. The female also made frequent bill movements. These included quick head or bill shaking movements, opening and closing her beak rapidly from one to six times, and slowly opening her beak wide until mandibles were nearly perpendicular and then snapping them closed.

The female frequently regurgitated seeds to the base of her bill before reswallowing them or rolled seeds to her bill tip before reswallowing. The female often increased the frequency of regurgitations before leaving the nest and on 10 occasions left carrying a seed in her bill tip. The red or red-brown drupe seeds were up to 15 mm long. She drank water droplets from her back and from leaves during rain on four occasions. She spent little time (18 occasions of <2 sec) preening, probing, or picking her feathers.

The female regurgitated seeds of a variety of sizes and shapes and thus, over the 22 days of observation, may have fed herself largely or exclusively on fruit. The nestling was fed exclusively on arthropods for the first five days of its life and thereafter occasionally was fed fruit (drupes) or pulpy mash that may have been figs. The feeding visit rate remained at slightly over one per hour except for 12 and 13 August when it increased sharply (Fig. 2).

The number of regurgitations of meal components (boluses) delivered per feeding visit increased after the fourth day (Fig. 2). The higher number of feeding visits per hour on 12 and 13 August coincides with a decrease in the number of boluses per feeding, and suggests that the total delivery of food was probably not different during those two days. Our impression is that bolus size increased during the nestling period, but data

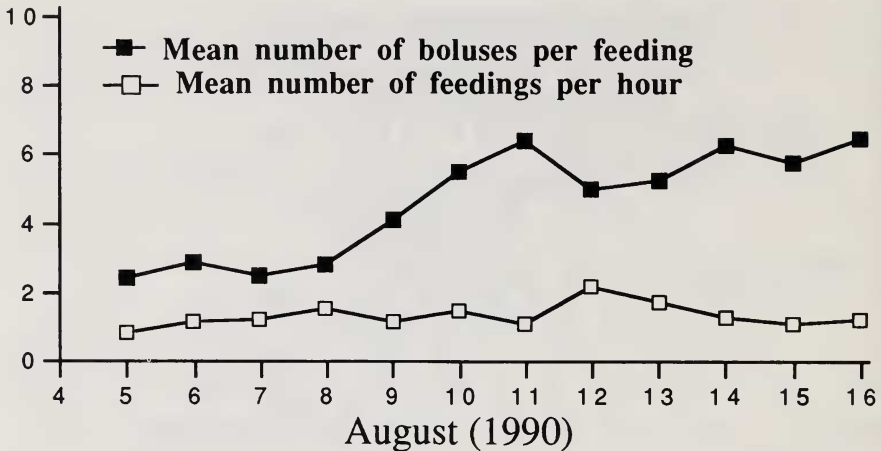


FIG. 2. Feeding frequency of nestling by female.

are inadequate to test this. Time invested in feeding the nestling did not change over the study (Fig. 3C). Time spent by the adult perched in the nest tree looking around before returning to the nest increased during the last two days (Fig. 3B). As the nestling aged, the female spent more time tending the nest and nestling (Fig. 3A). The female typically ate items picked from the nest cup immediately after feeding the nestling. She ate fecal sacs on more than a dozen occasions, never was observed carrying a fecal sac from the nest, and on three occasions took a fecal sac directly from the nestling's raised posterior. The largest fecal sac was estimated to be 25 mm (longest dimension).

The behavior of the female was cryptic. She typically looked around from the well-hidden nest for a few seconds before departing and looked around considerably longer before reentering the nest (Fig. 3B). We found no droppings under the nest tree and no regurgitated seeds or other evidence of food. The female frequently left the nest carrying seeds. She carried away the egg shell after the chick hatched.

The female sat quietly and still when predators were present. On 3 August, a Doria's Hawk (*Megatriorchis doriae*) perched 20 m from the nest tree and 31 minutes later perched 25 m from it. The female remained still throughout this period. Other potential predators, including a Brahminy Kite (*Haliastur indus*), Grey Crow (*Corvus tristis*), several Hooded Butcherbirds (*Cracticus cassicus*), and a Stout-billed Cuckoo-Shrike (*Coracina caeruleogrisea*), drew the same response as did passing mixed foraging flocks. Several small passerines perched in the nest tree, within two m of the nest, without drawing a response from the female Raggiana.

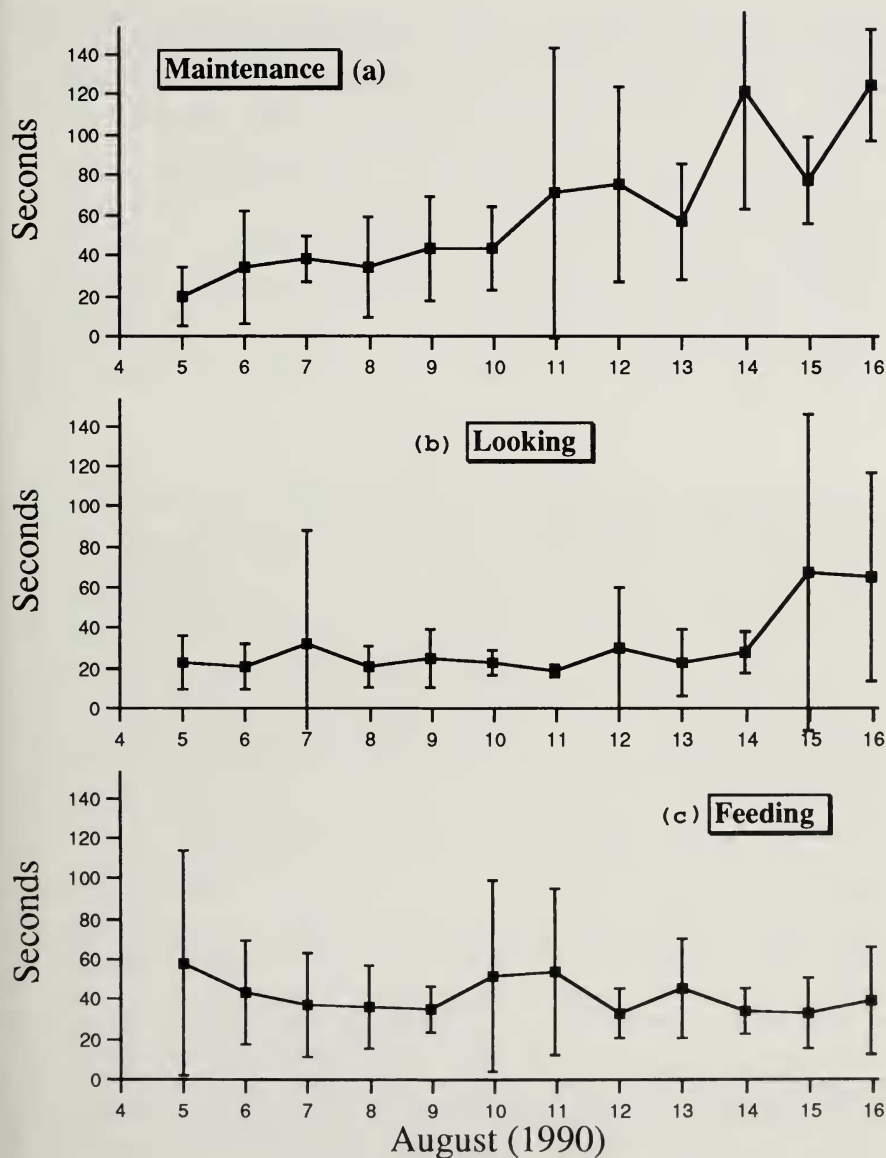


FIG. 3. Average time a female Raggiana Bird of Paradise spent in (A) nest maintenance following a nestling feeding bout, (B) looking around (typically from horizontal branch immediately below nest) before entering nest with food, and (C) feeding nestling. Bars indicate means \pm SD.

The only exception occurred when several female or young male Raggianas flew near the nest tree, and the female chased one of them from the area. Birds of paradise are known to predate nest contents (Beehler, pers. obs.). The chick appeared to be silent and only made itself visible above the nest cup when the female returned from foraging.

The dead nestling had the following measurements: mass = 100 g; tarsus = 38.8 mm; posterior gape to beak tip = 23.4 mm; bill tip to pygostyle = 130 mm; wing span = 196 mm. Feathers were largely ensheathed, leaving areas of skin bare. The nestling was male, had no evidence of infectious disease, exhibited "no specific gross or histologically identifiable cause of death," and death was "perinatal, stress-related" (R. Montali, pers. comm.). It weighed 54% of mean adult female mass (LeCroy 1981).

DISCUSSION

The time budget for the incubating female (Fig. 1) is consistent with that of frugivorous birds (Snow 1962, 1976). The female was able to provision herself and spend a majority of time incubating. Some sexually dimorphic frugivorous species (e.g., Crested Bird of Paradise [*Cnemophilus macgregorii*]) feed their offspring entirely on fruit (Frith and Frith 1993b), while others (e.g., Short-tailed Paradigalla [*Paradigalla brevicauda*] and Ribbon-tailed Astrapia [*Astrapia mayeri*]) feed their young arthropods and fruit (Frith and Frith 1992, 1993a). The Raggiana fed mostly arthropods to the young bird, and the difficulty in obtaining arthropods as compared to fruit may explain the shift to about two-thirds of the time foraging (Fig. 1). This reliance on arthropods for nestling diet is consistent with observations of provisioning of nestlings by four captive bird of paradise species: King (*Cicinnurus regius*) (Bergman 1957), Superb (*Lophorina superba*) (Timmis 1968), Raggiana (Dharmakumarsinhji 1943, Searle 1980), and Magnificent (*Cicinnurus magnificus*) (Everitt 1965).

Lill (1976) and Snow (1976) suggested that provisioning young is a fundamental constraint for bird species with female-only nest attendance. In this, diet and clutch size may play significant roles. The reliance on low-protein, low-lipid, high carbohydrate fruit by manucodes *Manucodia* spp. (Paradisaeidae) has been used as an explanation for the retention of monogamy in these species (Beehler 1983, 1985).

The reliance on arthropods for nestling diet may produce a nutritional bottleneck during nesting in the Raggiana Bird of Paradise. While this high reliance requires greater foraging time, the bird continues brooding during rain. We suggest that prolonged rain places the single parent Raggiana in a demanding situation: if she forages during the rain, she risks

losing her offspring to exposure, and if she broods, she risks weakening or starving her young. At Varirata, the Raggiana Bird of Paradise nests in the middle of the dry season, when risk of prolonged rains is minimal.

ACKNOWLEDGMENTS

We thank the Dept. of Environment and Conservation, Government of Papua New Guinea, for permission to conduct field research at Varirata National Park. Primary funding was provided by the National Geographic Society (grant 4026-89). The Biology Department, University of Papua New Guinea, provided logistical support, and Jack Dumbacher, Andrew E. Hare, Michael Lucas Simu, Rodney Goga, Bulisa Iova, and Jill and David Heath provided assistance in the field. Richard Montali conducted the necropsy of the nestling. We thank John C. Kricher for comments on early drafts of the manuscript. The manuscript benefitted greatly from the comments and suggestions of referees Clifford B. Frith and Stephen Pruett-Jones.

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